BANGALORE ELECTRICITY SUPPLY COMPANY LIMITED

Technical Specifications for RTU of RMU/SPB

Issued By

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1. Introduction

This document contains Technical Specifications that apply to**: Remote Terminal Units for RMU/SPB**, which covers supply, installation and integration of Remote Terminal Units (RTUs).

The RTUs that are to be supplied and installed in accordance with these Technical Specifications shall serve as remote DAS interfaces to RMU/SPB, which is connecting the RMU/SPB to its feeder main loop circuit. They shall allow the DAS to monitor & control these switches as well as monitor the information available and Intelligent Electronic Devices (IEDs) that are a part of RMU/SPB. The IEDs include multifunction meter and breaker protection relay.

The RTUs shall interoperate with the DAS at just one of the control centres at any given time utilizing a new communications system.

1.1 Specification Organization

These RTU Technical Specifications are organized as follows:

- **Clause 2 - RTU Design Features.** This includes requirements covering their availability, maintainability, expandability, life span, environmental, power supply, overload, surge withstand, noise level, assembly, component identification, and interconnection features.
- **Clause 3- RTU Characteristics**. The main characteristics are encompassed that relate to RTU functional, design, performance, equipment, enclosure, space, software/firmware, and test system features.
- **Clause 4 - RTU Inspection and Test.** This includes inspection, test procedures, test records, factory acceptance tests, and field performance test requirements for the RTUs.
- **Clause 5 - RTU Documentation.** This includes the documentation and design approval procedures and the hardware, firmware, test, and final documentation requirements.

2. RTU Design Features

The important RTU design features include:

- Availability, maintainability and expandability
- Ability to operate in specified outdoor ambient temperature and relative humidity conditions
- Overload and surge withstand capabilities
- Noise level
- Assembly and component identification
- Interconnections
- Support facilities

In these and all other specified respects, the RTU shall meet or exceed the standards cited herein or, where appropriate, other relevant industry standards.

2.1 Availability, Maintainability and Expandability

2.1.1 Availability

The RTUs shall exhibit an availability of 99.9% exclusive of communication channel availability. An RTU shall be considered unavailable when:

1) Any RTU function such as monitoring or control is lost for all points of a single type
2) One input card or output card of each type fails
3) More than one input card or output card of the same type fails

2.1.2 Maintainability

The RTU design shall facilitate isolation and correction of all failures. The following features, which promote rapid problem isolation and replacement of failed components, shall be included:

1) Self-diagnostic capabilities within each RTU that can be initiated from the DAS

2) On-line error detection capabilities within the RTU and detailed reporting of detected errors to the DAS

3) Local indication of RTU failures.

2.1.3 Expandability

Each RTU shall be expandable in the field solely by card or circuit module additions (the addition of enclosures, cables, chassis, or power supplies shall not be necessary).

2.2 Environmental Requirements

The RTUs shall be capable of operating in temperatures from 5ºC to +55º C, in relative humidity values from 10 to 95% non-condensing, and at altitudes of at least 1,000 m.

2.3 Overload Protection

Connection of high voltage sources to input and output terminals may occur during the life of the equipment. No damage shall occur to any input or output due to continuous normal mode overload of up to 120 V (dc or peak ac), or due to imposition of up to 240 V (dc or peak ac) between any terminal and ground. Recovery from either type of overload to nominal accuracy shall require less than 5 minutes. The effect on accuracy of either type of overload on any adjacent channel shall be less than 0.1% of full scale. Input overload response characteristics shall have been tested in accordance with an applicable international standard.

Overloads greater than specified above, but less than 600 V (dc or peak ac) may damage some components, but shall not result in propagation of any damage beyond the single input, output, or communication circuit at which the overload occurred.

2.4 Surge Withstand Capability

The RTUs shall be able to successfully undergo the tests described in ANSI C37.90a, Guide for Surge Withstand Capability (SWC) Tests (or equivalent). Application of the SWC wave form to any input or output, including the power input, communication ports of modbus and master communication channel connections,

shall not result in the loss of data from any input or output other than the input or output being tested. The RTU shall not reset or restart its internal logic as a result of the SWC wave form application, nor shall the contents of any internal memory be affected by the SWC testing. Dedicated surge protection devices (SPDs) shall be provided individually for the power supply, RS-232 communication port and meter-relay communication port.

2.5 Electrostatic and Electromagnetic Compatibility

The RTUs shall support the following requirements for electrostatic and electromagnetic compatibility for a 1 kV voltage:

1) Electrostatic Discharge: The equipment shall meet the requirements of the test in IEC 61000-4-2 Level 2.
2) Radiated Electromagnetic Field Disturbance: The equipment shall meet the requirements of IEC 61000-4-3 Level 2.
3) Conducted and Radiated Interference: The equipment shall meet the requirements of CISPR 22 Class A.
4) Surge Immunity: The equipment shall meet the requirements of IEC 61000-4-5 Level 2 for both signal and power ports

2.6 Noise Level

The audible noise generated by the RTU equipment shall not exceed the values for noise criteria curve NC-45 as described in ANSI C37.l (as extracted from MILSTD-l472) or equivalent.

2.7 Assembly and Component Identification

Each assembly, to the level of printed circuit cards, shall be clearly marked with the manufacturer's part number and serial number along with component revision levels. Changes to assemblies shall be indicated by an unambiguous change to the marked revision level.

All electronic parts, such as capacitors, resistors, and integrated circuits, shall be marked either with the characteristics of the part or with an industry standard part number. Where custom components are provided, such as read only memories, the

component shall be marked so as to specifically identify where similar parts may be obtained.

All printed circuit card cages and all slots within the cages shall be clearly labeled. Plug-in cards or modules shall be keyed to prevent incorrect insertion or insertion into incorrect locations. Alternatively, if the design enables different types of plug-in cards to occupy any configurable slot location, no damage or malfunction shall occur if the incorrect card is plugged into a pre-configured slot, and the system shall properly identify the error.

2.8 Interconnecting Cables and Wiring

The Contractor shall provide all interconnecting wires, cables, connectors, terminations, and other wiring accessories required to connect the RTUs to all relevant RMU/SPB terminals. This shall include, but not be limited to, a 1.5m meter relay communication cable, a 1.5m 24V power supply cable and a 2m LAN cable. However, the exact length of the cables will be finalized during the design phase. All such wiring and cabling, including wires and cables between component units of the RTU, shall be shown on Contractor-supplied drawings.

All wires and cables supplied by the Contractor shall use copper conductors and have flame retardant insulation and shall be neatly laced and clamped.

Each end of interconnection cables shall be identified by a marker, which includes the cable number, identifying number and location of each of the cable's terminations; this information shall agree with Contractor's drawings. All logic card & cable terminations shall be adequate to prevent contamination. All connection points for external cables & wires shall be easily accessible for connection and disconnection. Conductors in multi-conductor cables shall be individually color-coded.

2.8.1 RMU/SPB-RTU Interface Connectors

To facilitate installation and maintenance, communication port and power supply connections not with standing, plug-type connectors shall be used to interconnect each RTU with its associated RMU/SPB. In this respect, cabling between RMU/SPB status and control points to be brought out by the RMU/SPB–to a set of hooded 24-pin female connectors fixed within the RMU/SPB enclosure that will house the RTU. Consequently, to connect the RTU to the RMU/SPB, the Contractor shall provide a

corresponding set of hooded 24-pin male connectors wired back to the RTU via a suitable cable.

The housing containing female connectors will contain a lever capable of locking the female and male connectors together. This lever shall be fully locked only if the two connectors are correctly mated.

Each 24 pin female connectors will be provided with guide pins as illustrated in Table 2.1 and 2.2, this will ensure the Same Connector of RTU will fixed to same connector of RMU/SPB

Labelling of all 24 Pin Connectors should be legible visible

Each RMU/SPB will be outfitted with a set of six for RMU/two for SPB 24-pin female connectors. In turn, therefore, the supplier shall provide the corresponding set of 6 for RMU/2 for SPB x 24-pin male connectors. These male connectors shall be wired by cable to the RTU, which in all cases shall be supplied & installed by the Contractor in a configuration sized for single breaker SCADA-ready RMU/SPB.

A possible pin-out arrangement is illustrated conceptually in Table 2.1 and 2.2 below. However, the pin-out arrangement will be finalized during design phase.

Terminal Blocks:

If metallic cable terminations other than those corresponding to the connectors specified, prove necessary, the Contractor shall provide heavy-duty terminal blocks with screw type terminals for 5 mm minimum machine screws. Terminals for auxiliary relays, if any, shall equal or exceed the relay wiring requirements. In using a terminal block, no more than two cables or wires shall be connected to any of its individual terminals.

Self-extinguishing fireproof vinyl marking strips shall be used to identify all external connection blocks. Marking tags shall be read horizontally. All terminals to which battery or other high voltages are connected shall be provided with fireproof covers.

If relevant, all individual status input, AC voltage input, and control output points shall be isolatable without the need to remove wiring by means of individual terminal blocks of the removable link type. In order to avoid open circuits on the secondary side of CTs, termination blocks with by-pass bridges shall be provided for all AC current inputs.

Table 2.1:

RMU/RTU Connector Pin-Out (List is tentative and will be finalzed during design phase)

RMU/RTU Connector Pin-Out																	
Pin Nos		LBS 1 (OD 1)	Pin Nos		LBS 2 (OD 2)	Pin Nos		Miscellaneous	Pin Nos		CB 1 (VL 1)	Pin Nos		CB 2 (VL 2)	Pin Nos		CB 3 (VL 3)
1	2	LBS 1: closed	1	2	LBS 2: closed	1	2	SF6 pressure: low	1	2	CB 1: closed	1	2	CB 2: closed	1	2	CB 3: closed
3	4	LBS 1: open	3	4	LBS 2: open	3	4	Charger AC: fail	3	4	CB 1: open	3	4	CB 2: open	3	4	CB 3: open
5	6	LBS 1: VPIS Indication	5	6	LBS 2: VPIS Indication	5	6	Voltage DC: low	5	6	CB 1: Spring/Motor charged	5	6	CB 2: Spring/Motor charged	5	6	CB 3: Spring/Motor charged
7	8	LBS 1 Earth switch: closed	7	8	LBS 2 Earth switch: closed	7	8	Battery: fail	7	8	CB 1 Earth switch: closed	7	8	CB 2 Earth switch: closed	7	8	CB 3 Earth switch: closed
9	10	LBS 1 Earth switch: open	9	10	LBS 2 Earth switch: open	9	10	Battery temperature	9	10	CB 1 Earth switch: open	9	10	CB 2 Earth switch: open	9	10	CB 3 Earth switch: open
11	12	Spare	11	12	FPI: OCR operated	11	12	Door: Control Cabinet	11	12	CB 1: VPIS Indication	11	12	CB 2: VPIS Indication	11	12	CB 3: VPIS Indication
13	14	DI indication for execution of DO command for open and close of LBS 1	13	14	FPI: EFR operated	13	14	Battery Compartment Door Open	13	14	DI indication for execution of DO command for open and close of CB 1	13	14	DI indication for execution of DO command for open and close of CB 2	13	14	DI indication for execution of DO command for open and close of CB 3
15	16	LBS 1: Local/remote status	15	16	LBS 2: Local/remote status	15	16	DI indication for execution of DO command for open and close of LBS 2	15	16	CB 1: L/R Switch Local Status	15	16	CB 2: L/R Switch Local Status	15	16	CB 3: L/R Switch Local Status
17	18	LBS 1 Control: close	17	18	LBS 2 Control: close	17	18	Hooter Reset	17	18	CB 1 Control: close	17	18	CB 2 Control: close	17	18	CB 3 Control: close
19	20	LBS 1 Control: open	19	20	LBS 2 Control: open	19	20	Spare	19	20	CB 1 Control: open	19	20	CB 2 Control: open	19	20	CB 3 Control: open
21	22	LBS 1: Cable entry Door open	21	22	LBS 2: Cable entry Door open	21	22	Spare	21	22	CB 1: Cable entry Door open	21	22	CB 2: Cable entry Door open	21	22	CB 3: Cable entry Door open
23	24	Spare	23	24	FPI: Remote reset	23	24	Spare	23	24	CB 1 Disconnector: open/close	23	24	CB 2 Disconnector: open/close	23	24	CB 3 Disconnector: open/close

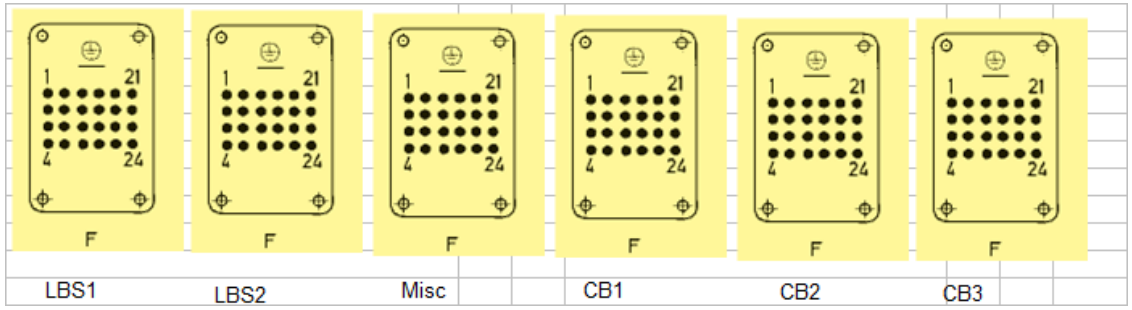
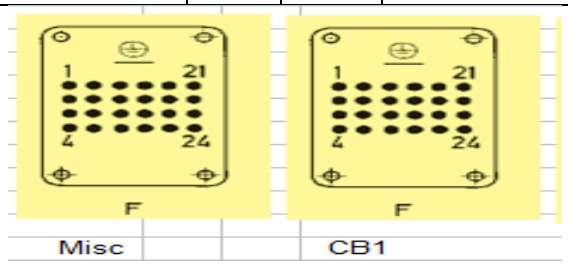

1
21
4
24
F
LBS1
LBS2
Misc
CB1
CB2
CB3

Table 2.2:

SPB/RTU Connector Pin-Out (List is tentative and will be finalzed during design phase)

Pin Nos		CB	Pin Nos		Miscellaneous
1	2	CB : closed	1	2	SF6 pressure : low
3	4	CB : open	3	4	Charger AC: fail
5	6	CB Spring/Motor charged	5	6	Voltage DC: low
7	8	CB Earth switch: closed	7	8	Battery: fail
9	10	CB Earth switch: open	9	10	Battery temperature
11	12	Spare	11	12	Door: Control Cabinet
13	14	Spare	13	14	Battery compartment door :open
15	16	CB L/R Switch Local Status	15	16	DI indication for execution of DO command for open and close of CB
17	18	CB Control: close	17	18	Hooter Reset
19	20	CB Control: open	19	20	Incoming cable entry door open
21	22	Outgoing cable entry door open	21	22	Incoming VPIS indication
23	24	CB Disconnector: open/close	23	24	Outgoing VPIS indication



Terminal blocks shall comply with IEC 60947-7-1: 2009 Low-voltage switchgear and control gear - Part 7-1: Ancillary equipment - Terminal Blocks for Copper Conductors. The LB may be read as OD and CB may be read as VL where necessary.

2.8.2 Support Facilities

The Employer intends to be self-reliant for both RTU hardware and firmware maintenance. To this end, the Contractor shall provide the support hardware, software, firmware, and documentation necessary to configure and repair the RTU. This shall include, but not be limited to, communication interfaces, printed-circuit card extenders, test cables, PROM programmer, maintenance manuals, RTU database compiler, firmware listings, RTU configuration listings, or other support facilities as applicable to the Contractor's RTU design.

3. RTU Characteristics

3.1 RTU Functions

The Contractor shall use as much standard hardware and firmware as possible; however, all of the functional requirements of this document must be satisfied.

3.1.1 Data Acquisition

The RTUs shall collect power system data including RMU/SPB data. In this respect, the Contractor shall provide all necessary equipment for assigning data points to the RTU database. Further, using the 24 Vdc source from the RMU/SPB power supply unit, the necessary wetting voltage, sensing voltage, current limiting, input isolation, and bounce filtering for all status (digital) inputs. The de-bounce time period for each status input shall be individually user configurable, and the input circuits of the status input modules shall be optically isolated from the external signal.

As a minimum, this data acquisition shall include DI points of Table 3.1 and 3.2.

Single as well as double status points shall be supported, where the latter relate to three-state switch positions reported in the form of two bits capable of representing one of four possible states, i.e., open, closed, in-transit, or indeterminate.

IED Input Data

a) Meter Data

The RTU shall be capable of reading data from the 1(one) multifunction meters that will be provided with each RMU/SPB multifunction meter, will measure electric power values such as voltage, current, active and reactive power, power factor, phase angle, and active and reactive energy. They will be of 0.2 accuracy class and will provide data on a RS 485 communications port when polled by the RTU using the MODBUS protocol.

b) Protection Relay Data

The RTU shall be capable of reading of one realy (3) phase currents measured by each RMU/SPB protection relay corresponding RMU/SPB. The phase currents shall be read using MODBUS and the relay RS 485 communications port. In addition, depending on the relay specific features, the RTU shall be capable of interoperating with the relay using any other communicable I/O point as may be available. The RTU shall also monitor relay operations by having the relay auxiliary contacts hardwired to the RTU.

The contractor shall follow the BESCOM standard Modbus addressing scheme irrespective of the make and model of the meter and protection relay.

3.1.2 Device Control

The RTU shall provide the DAS with the capability to select and control, i.e., open and close the RMU/SPB.

Each RTU shall be equipped with a manual switch that can be placed in one of two positions, i.e., “local” or “remote.” The local position shall disable RMU/SPB device control from the DAS, whereas the remote position shall enable RMU/SPB device control from the DAS. Otherwise, in its local position, the switch shall not prevent:

(a) The RTU from monitoring and reporting RMU/SPB measurement and status data to the DAS

(b) The RTU panel from being used to control the RMU/SPB devices.

An auxiliary contact on the switch shall be wired to a contact input in the RTU to report the switch's local/remote status to the DAS.

The Contractor to supply the interfaces to the RMU/SPB actuators and control devices. Signal interfaces to the RTU will be via signal quality potential-free contacts and also provide any necessary interposing relays for any digital output to the control gear within the RMU/SPB enclosures. This includes the DC voltage to drive the interposing relay.

3.1.3 Local Operator Smart Display

The Contractor shall provide a Smart Display–based Local Operator Panel designed and suitable for RMU/SPBs for local monitoring, control, alarm indication, and event recording. The Smart Display shall be a full-colour high-resolution LCD/IPS type with a minimum resolution of 480 × 272 pixels (or higher), capable of clearly displaying dynamic single-line mimic diagrams of RMU/SPB's configuration & status indications, numerical parameters, alarm lists and event logs. The panel shall include a minimum of 16 configurable alarms and status LED's.

In addition, with the RTU local/remote switch in its local position, the panel shall include dedicated Trip and Close buttons along with switch select allowing Local control of all LBs and CBs of RMU/SPB. The buttons have to be configured with a range of security options. The unit shall incorporate an integrated Sequence of Events (SOE) recorder with 1 millisecond time-stamping accuracy and sufficient non-volatile memory for event storage. Dedicated navigation keys shall allow the user to move around and between displays.

The Smart Display and associated controls shall be of rugged industrial design, suitable for panel mounting in RMU/SPB compartments, and capable of reliable operation under typical RMU/SPB environmental conditions including temperature variations, humidity, vibration, and electromagnetic interference.

3.1.4 RTU Front Panel

Each RTU shall have a front panel equipped with "Local Operator Smart Display" described in Clause above.

The RTU front panel shall be equipped with suitable connectors and ports including, for example, an RS 232 (sub-D 9) connector or through OFC converter and one or more USB ports. These connectors and ports shall allow a laptop PC to be connected to the RTU for the purpose of performing local RTU configuration and diagnostic activities.

3.1.5 Input /Output Point Counts

All RTUs shall be sized and equipped so that they can be used by the DAS to monitor and control RMU/SPB. On this basis, the RTUs shall be wired to the RMU/SPB serial communication ports or through OFC convertor and to the RMU/SPB I/O points (including spares) using the connectors. For further I/O details refer to Tabel 3.1 and 3.2.

All points, including the spares as shown in Table 3.1 and 3.2, shall be fully configured and available for Employer use. However, the Input/Output points will be finalzed during design phase.

3.1.6 PLC Capability

The RTU shall have Programmable Logic Control (PLC) capability. In this respect, the PLC shall comply with the IEC 61131-3 programming standard.

3.2 RTU Equipment Characteristics

3.2.1 Interface with RMU/SPB Multi-Function Meters and Numerical Relays

The RTU shall interface with the RMU/SPB multi-function meter and numerical relay using an RS 485 serial communications link and the MODBUS protocol. Wiring, cable, terminal, and data mapping details shall be finalized in conjunction with the RMU/SPB. Communication cable lengths up to 6 m are anticipated. The RTU shall act as a master for time synchronization and time sync signals shall be issued from the RTU to the relay.

The RTU shall have the capability to receive write commands from the Master Control Center and securely write set-point and control values to connected protection relays via supported Modbus protocols.

Table 3.1:

RMU-RTU Data Point Count (List is tentative and will be finalized during design phase)

DIGITAL INPUT	**CONTROL OUTPUT**	**IED DATA**
LBS 1 ▪ LBS 1: closed ▪ LBS 1: open ▪ LBS 1: VPIS Indication ▪ LBS 1 Earth switch: closed ▪ LBS 1 Earth switch: open ▪ LBS 1 local/remote status ▪ LBS 1 Cable entry Door: open ▪ DI indication for execution of DO command for open and close of LBS 1 **LBS 2** ▪ LBS 2: closed ▪ LBS 2: open ▪ LBS 2: VPIS Indication ▪ LBS 2 Earth switch: closed ▪ LBS 2 Earth switch: open ▪ LBS 2 local/remote status ▪ LBS 2 Cable entry Door: open ▪ DI indication for execution of DO command for open and close of LBS 2 FPI ▪ Overcurrent operated ▪ Earth fault operated	**LBS 1** ▪ LBS 1: close ▪ LBS 1: open **LBS 2** ▪ LBS 2: close ▪ LBS 2: open **CB 1** ▪ CB 1: close ▪ CB 1: open **CB 2** ▪ CB 2: close ▪ CB 2: open **CB 3** ▪ CB 3: close ▪ CB 3: open **FPI** ▪ FPI Reset **Miscellneous:** ▪ Hooter Reset **Total: 12** **Total (with spares): 16**	Multifunction Meters communications on MODBUS through RS485 ports (2 meters) No. of Measurements: ▪ Voltage: 6 ▪ Current: 6 ▪ Active power: 2 ▪ Reactive power: 2 ▪ Power factor: 2 ▪ Active Energy: 2 ▪ Reactive Energy: 2 ▪ Phase angle current: 6 ▪ % THD: 2 **Total Measurements: 30** Feeder Protection Relays communications on MODBUS through RS485 ports (up to 3 protection relays) Minimum No. of Points: ▪ Phase Current: 9 ▪ Fault current: 9 ▪ EFR Fault current: 3 ▪ Relay Ie Earth Current: 3 ▪ Relay Fault Type: 3 ▪ Relay Trip Time: 3 (Time taken for relay and breaker operation during fault event) ▪ Relay Group A/B Active: 3 ▪ Relay Reset mode Local/Auto: 3 ▪ Circuit Breaker Failure Protection: 3 ▪ Relay OCR operated: 3 ▪ Relay EFR operated: 3

RMU-RTU Data Point Count (Continued…)

DIGITAL INPUT	CONTROL OUTPUT	IED DATA
CB1 ▪ CB 1: closed ▪ CB 1: open ▪ CB 1 Spring/Motor: charged ▪ CB 1 Earth switch: closed ▪ CB 1 Earth switch: open ▪ CB 1 local/remote status ▪ CB 1 Cable Entry Door: open ▪ CB 1 Disconnector status: open/close ▪ CB 1: VPIS Indication ▪ DI indication for execution of DO command for open and close of CB 1 **CB2** ▪ CB 2: closed ▪ CB 2: open ▪ CB 2 Spring/Motor: charged ▪ CB 2 Earth swttch: closed ▪ CB 2 Earth switch: open ▪ CB 2 local/remote status ▪ CB 2 Cable Entry Door: open ▪ CB 2 Disconnecot status: open/close ▪ CB 2: VPIS Indication ▪ DI indication for execution of DO command for open and close of CB 2 **CB3** ▪ CB 3: closed ▪ CB 3: open ▪ CB 3 Spring/Motor: charged ▪ CB 3 Earth switch: closed ▪ CB 3 Earth switch: open ▪ CB 3 local/remote status ▪ CB 3 Cable Entry Door: open ▪ CB 3 Disconnector status: open/close ▪ CB 3: VPIS Indication ▪ DI indication for execution of DO command for open and close of CB 3 **Miscellaneous:** ▪ SF6 Pressure: Low ▪ Charger AC: Fail		▪ Relay group change A/B: 3 ▪ Relay reset mode change: local/ auto: 3 ▪ Relay reset OCR/EFR: 3 ▪ RTC Time Sync with Relay: 3 ▪ Low set Settings for OCR and EFR: 3 ▪ High set Settings for OCR and EFR: 3 **Total Points: 63**

DIGITAL INPUT	CONTROL OUTPUT	IED DATA
▪ Voltage DC: Low ▪ Battery: fail ▪ Door: Control Cabinet ▪ Battery Compartment Door Open ▪ Battery temperature <u>General:</u> ▪ Dummy Latching Relay Open/Close ▪ RTU Local/Remote Status ▪ RTU Door Open **Total: 54** **Total (with spares): 64** <u>Soft signals:</u> ▪ Meter Offline: 2 ▪ Relay Offline: 3 ▪ DI point for DO execution of RMU		

Table 3.2:
SPB-RTU Data Point Count (List is tentative and will be finalzed during design phase)

DIGITAL INPUT	CONTROL OUTPUT	IED DATA
CB ▪ CB : closed ▪ CB : open ▪ CB Spring/Motor: charged ▪ CB Earth switch: closed ▪ CB Earth switch: open ▪ CB local/remote status ▪ Outgoing cable entry door open ▪ CB Disconnector status: open/close **Miscellaneous:** ▪ SF6 Pressure: Low ▪ Charger AC: Fail ▪ Voltage DC: Low ▪ Battery: fail ▪ Battery temperature ▪ DI indication for execution of DO command for open and close of CB ▪ Incoming cable entry door open ▪ Door: Control Cabinet ▪ Battery Compartment Door Open ▪ Incoming VPIS indication ▪ Outgoing VPIS indication General: ▪ Dummy Latching Relay Open/Close ▪ RTU Local/Remote Status ▪ RTU Door Open **Total: 22** **Total (with spares): 32** Soft signals: ▪ Meter Offline ▪ Relay Offline ▪ DI point for DO execution of RMU	**CB** ▪ CB : close ▪ CB : open **Miscellneous:** ▪ Hooter Reset **Total: 3** **Total (with spares): 8**	Multifunction Meters communications on MODBUS through RS485 ports (1 meter) No. of Measurements: ▪ Voltage: 3 ▪ Current: 3 ▪ Active power: 1 ▪ Reactive power: 1 ▪ Power factor: 1 ▪ Active Energy: 1 ▪ Reactive Energy: 1 ▪ Phase angle current: 3 ▪ % THD: 1 **Total Measurements: 15** Feeder Protection Relays communications on MODBUS through RS485 ports (one protection relay) Minimum No. of Points: ▪ Phase Current: 3 ▪ Fault current: 3 ▪ EFR Fault current ▪ Relay Ie Earth Current ▪ Relay Fault Type ▪ Relay Trip Time (Time taken for relay and breaker operation during fault event) ▪ Relay Group A/B Active ▪ Relay Reset mode Local/Auto ▪ Circuit Breaker Failure Protection ▪ Relay OCR operated ▪ Relay EFR operated ▪ Relay group change A/B ▪ Relay reset mode change: local/ auto ▪ Relay reset OCR/EFR ▪ RTC Time Sync with Relay ▪ Low set Settings for OCR and EFR ▪ High set Settings for OCR and EFR **Total Points: 21**

3.2.2 External Communications Interface

The RTUs shall have two ports available for the primary means of communicating with the DAS via the Employer's communications system. One shall be an Ethernet TCP/IP (RJ45) port, and one shall be a Serial (RS-232C) port / through OFC convertor port. Both ports shall be capable of operating at 9.6 kbps (or higher) in conjunction with OFC or other communications system provided by others. Only one of these ports, however, shall be used for DAS communications at any given time.

The port that is not used for primary communications may be used for other purposes such as:

1) Local testing using the RTU test kit

2) Through fibre converter

3) Any other communication proposal during design phase

In this respect, all external services and devices (such as modems or OFC) will be provided by the Employer.

3.2.3 Communication Protocols

With reference to Clause above, the RTU Ethernet and Serial ports shall support DNP 3.0 and DNP/IP Protocols. The RTU shall support DNP secured authentication. The RTU shall also support the DNP3 protocol as per IEEE 1815, specifically implementing and demonstrating Secure Authentication. This must include support for pre-shared keys, user authentication and integrity checks to prevent unauthorized control or spoofing. The Communication protocol shall be finalized during design phase.

In addition to these protocols, the RTU port for communications with the RMU/SPB's multifunction meter and protection relay shall use MODBUS.

All protocols shall be implemented by modifiable firmware in the RTU. No external gateways for protocol conversions shall be necessary.

The Employer shall be authorized to disclose the RTU protocol implementation profiles to third-party contractors of Employer equipment. In the case of DNP, relevant profile and data mapping details shall be coordinated.

3.2.4 Status/Analog Reporting Modes

Power system input data collected by the RTU shall be able to be reported to the DAS Master Station using the following possible modes of operation:

1) Report by Exception: The RTU shall report status/analog changes by exception. That is, the RTU replies to a DAS Master Station scan command by sending only the status/analog changes that have occurred during the scan time interval.

2) Unsolicited: The RTU shall report status/analog changes in an unsolicited spontaneous manner. That is, the RTU itself reports to the DAS any change to the status/analog points collected without the need of a scan command from the DAS.

3) General Interrogation: The RTU shall report all status/analog values in response to a cyclic DAS general scan command.

4) Demand Interrogation: The RTU shall report selected status/analog points in response to a DAS demand scan request

Scan rates and deadbands (used to detect significant analog changes) shall be programmable. In addition, deadbands shall be programmable on an individual point basis.

3.2.5 Select-Check-Before-Execute Control Security

Control output implementations shall apply a select-check-before-execute command sequence. The control sequence shall include, as a minimum, the following capabilities:

1) The DAS shall transmit a command message addressing the proper RTU and control point within the RTU as well as indicating the control action desired.

2) The RTU shall initialize its control logic, reassemble the command message, and transmit the reassembled message to the DAS. The message sent to the DAS shall be generated by the RTU's point selection logic; it shall not be a simple repeat of the DAS transmission.

4) The DAS shall check the returned message for validity and, if valid, shall issue an execute command to the RTU.

5) The RTU shall only operate the control point selected, and only after the execute command has been received.

The control action shall be executed only if the select-check-before-execute sequence is performed without error or interruption by other messages. The RTU shall reset its control logic upon any error in the sequence or if the execute command is not received within a software engineer-definable time, typically 10 seconds, after the command message is received by the RTU.

3.2.6 Message Security

Each message transmitted shall include an error detection code to exclude erroneous messages being accepted as valid.

3.2.7 Control Simulation Test Facilities

Each RTU shall be equipped with an internal mechanism for simulating the response to a control output message. This control simulation facility shall be capable of being linked to any control point in the RTU. This facility shall simulate the change of state and the state indication of the linked point upon receipt of a valid control output message from the DAS or from locally applied test equipment.

3.2.8 RTU Time Synchronization

The RTUs shall have an internal clock with battery for data collection coordination and time tagging with a drift of no more than 1 second per day, which corresponds to a clock accuracy of 10 ppm. To meet this requirement, the RTU may apply a time correction algorithm. RTU shall be designed such that, during restart or power restoration, the system does not go to default time and remains synchronized with DAS/SCADA using an internal clock battery-supported RTC (Real Time Clock).

The RTU time source shall support the capability of the RTU to time tag operations data (i.e., real-time data) and, for possible future application, non-operations data used for post-mortem analysis. The non-operations data could include power quality data such as disturbance and waveform records.

Each RTU shall synchronize its internal clock from the DAS through the DNP communications protocol. Alternatively, should it be necessary, the RTU shall support time synchronization via the Network Time Protocol (NTP).

Contractor shall provide additional RTU internal clock battery as spare before expiry of the warranty period.

3.2.9 Power Supply

The RTUs shall make use of the 24 Vdc source of power furnished by the RMU/SPB supplier and, on this basis, the RTU input and output circuits shall be capable of operating reliably for any voltage between 16 and 32 Vdc. The RTUs shall be capable of operating with ungrounded or grounded (i.e., either polarity) input power. The RTUs, however, shall not place a ground on the input power.

3.2.10 Enclosures and Space Requirements

The RTUs shall be supplied in galvanised or stainless-steel enclosures having a protection index of at least IP54. The Contractor shall specify the unit dimensions as well as the installation requirements. The final physical dimensions of the RTU shall be finalized during the design phase.

Within this context, the RTU enclosures shall meet the following specific requirements:

1) They shall be capable of being accommodated within the RMU/SPB control cabinet enclosures.

2) They shall have lockable doors allowing maintenance access to the hardware and wiring. Swing racks supported by heavy gauge hinges shall be provided so that only front access to components and wiring is required for routine maintenance and troubleshooting.

3) They shall have provisions for top and bottom cable entry. Cable entries shall be provided with protection against insect and animal entry, and shall be sealed to prevent dust and sand contamination.

4) There shall be suitable signal and safety ground networks within the enclosure. The safety ground shall be isolated from the signal ground and shall connect to the ground wire of the power input. The signal ground shall terminate at a separate stud connection sized for a lugged 2/0 ground wire. Each ground network shall be a copper bus bar, braid, or cable. Use of the enclosure frame, skins, or chassis mounting hardware for the ground network is not acceptable

3.3 RTU Software/Firmware

The RTUs shall meet the following software/firmware requirements to support the functions of the RTUs. The term firmware, as used herein shall mean PROM-based and user friendly software which may be provided to satisfy the Employer's requirements. The Contractor shall use standard firmware as much as possible.

3.3.1 Design Characteristics

All firmware shall be completely and consistently documented. It shall not be necessary to perform modification to firmware, logic, or data for expansion within the sizing parameters defined for the RTU.

At the time the RTU is accepted, all firmware delivered must be up to date and in final form, including all standard firmware changes and field changes initiated by the Contractor or any associated sub-contractor prior to acceptance. The firmware documentation must reflect these changes.

3.3.2 Initialization/Restart Program

Firmware shall be provided to enable the RTU to safely restart itself upon manual request and automatically under the conditions of power restoration, memory parity errors, RTU freeze and hardware failures. The firmware shall initialize the RTU and begin execution of the RTU functions without intervention by the DAS. All RTU restarts shall be reported to the DAS.

3.3.3 RTU Operations Monitoring Firmware

Firmware shall be provided to continuously monitor operation of the RTU and report its hardware errors to the DAS. The firmware shall check for memory, CPU, communication faults, and input/output errors and failures. All detected errors shall be reported to the DAS.

3.3.4 Fail Safe Processing

In the case of irrecoverable faults such as power supply failures, firmware malfunctions, or any other detected condition that may affect the security of indications and controls, the RTU shall place itself in a secure state that prohibits the transmission of false indications or the execution of erroneous control outputs. The detection of these error conditions shall be the responsibility of the RTU’s self-test and operations monitoring firmware.

3.3.5 Database Maintenance

The Contractor shall supply software to configure each RTU's database where this information is located in software and/or firmware at the RTU. The software shall completely generate or modify the database of the RTUs. The database software shall have error detection services and shall produce a printed listing of the input data and the resulting RTU database configuration.

The RTU shall support changes made to the RTU's configuration and processing parameters (such as measurement deadbands) by downloading relevant data from the DAS. The contractor shall provide a single file for download. The RTU shall display the name and version of the current Configuration file in the RTU web page.

The RTU shall support deadband functionality with both read and write capability. It shall be possible to configure, modify, and read back deadband values for analog points from the SCADA/DAS system or engineering workstation without requiring RTU restart.

3.3.6 Diagnostic Firmware

The Contractor shall supply diagnostic firmware for both off-line local tests and on-line self-diagnostic capability built into the RTU. The RTU shall enter an off-line state during the execution of off-line diagnostics, and this off-line state shall be reported to the DAS.

3.3.7 Diagnostic Ports

The RTU Ethernet and Serial communication ports shall be capable of being used for remote diagnostics from the DAS and from any external computer terminal with a suitable communications connection.

3.3.8 Data Security

The RTU shall support cyber security conformance testing of communication protocols as per the guidelines of Ministry of Power, Government of India and its amendments.

The RTU shall be tested for DNP3.0 secure, DNP 3.0 & DNP IP in a lab certified by Government of India for which protocol specified, if such a facility is not available in India, contractor to facilitate the protocol testing when such facilities are available.

The Contractor shall work closely with the Employer to ensure no system security is compromised by the design of the system.

Provision to be made for securing the external access through MAC binding.

Passwords for maintenance access shall be constructed to maximise the amount of computer processing required to guess the password. The System shall provide facilities to support the following requirements:

1) A combination of upper and lower case alphabetic, numeric and special characters shall be used.

2) The minimum password length shall be configurable by the Employer, and initially set to 7 characters.

3.3.9 RTU test sets

The Contractor shall supply RTU test sets for performing the functions listed below. Laptop PCs shall be used for this purpose. The RTU test system shall comply with the following requirements:

1) Each test system shall support all maintenance aspects such as verifying proper operation, troubleshooting, reconfiguring, and setting operational parameters for the RTUs.
2) The test systems shall support all functional capabilities of the RTUs, including functions that are not explicitly required in these Technical Specifications and functions that may not be included in the delivered RTUs.
3) It shall be possible to use a test system locally at the site of the RTU under test, and also remotely wherever access can be obtained to the communication channel of the RTU.
4) All the required data rates shall be easily selectable.
5) It shall be possible to use the test systems to monitor communications between the DAS and the RTUs by selecting specific data streams, or portions of such data streams, both to and from an RTU. The data shall be displayed in a form that is easy for the user to interpret.
6) It shall be possible to connect the test system directly to the RTU and to use the test system to perform all necessary RTU management and expansion functions, monitor all stored data, monitor RTU inputs, exercise RTU outputs, and diagnose and troubleshoot the RTU. It shall also be possible to use the test system as a local user interface at the RTU location.
7) No programming skills shall be required to use the field test system. Interactive procedures relying mostly on pull down menus shall be used. The user shall not be required to type in commands, and shall be prompted when data entry is needed.
8) The test systems shall be ruggedly constructed and suitable for field work and transportation in trucks. All cables, connectors, equipment, and documentation

associated with their operation shall be included and stored either within the test system package or in suitable separate containers.

9) The test systems shall operate on internal battery and 230 Vac, 50 Hz.

All RTU test sets provided shall be equipped with Licensed Antivirus Software. The software must be capable of offline updates and configured to prevent the spread of malware during field testing and commissioning.

The hardware shall include Intel Core i5 or higher Processor (CPU), 16 GB or higher Memory (RAM) and 512 GB or higher Storage. The software shall include currently supported version of Windows Pro (latest version), hardened by disabling non-essential services, guest accounts, and unused ports (Bluetooth/IR).

"Auto-run" shall be disabled for all removable media as a part of USB hardening.

User Account Control (UAC): Field technicians should use a "Standard User" account for daily testing. Admin privileges should only be used for software installation or critical configuration changes, protected by a strong password or biometric.

4. RTU Inspection and Test

All RTU materials including hardware, firmware, and associated equipment and devices to be furnished and all work to be performed under this Specification shall be subject to inspections and tests. No RTUs materials shall be shipped until all required inspections and tests have been made, demonstrating that they conform to the Specification and have been approved for shipment by the Employer.

Approval of inspection and test results, acceptance of RTU materials or the waiving of inspection and tests thereof, shall in no way relieve the Contractor of the responsibility for furnishing materials that meet the requirements of this Specification, nor shall such actions invalidate any claim that the Employer may make because of defective or unsatisfactory RTU materials. The Employer reserves the right to request additional tests on the RTUs at no extra charge in connection with any work

the Employer determines not to be in accordance with these Technical Specifications.

Whenever the results of any inspections or tests performed or requested by the Employer in accordance with the requirements of this Clause indicate that specific hardware, firmware, electrical equipment, devices or documentation does not meet the specified requirements, the Contractor shall replace, modify, or add, at no cost to the Employer, RTU hardware, firmware, electrical equipment, devices, or documentation as necessary to correct the noted deficiencies.

4.1 Inspection

Representatives of the Employer shall have free entry into the facilities of the RTU and electrical equipment manufacturers at any time while design, fabrication, or testing of the equipment is taking place and into any mill, shop, or factory where the hardware or firmware described in these Technical Specifications is being produced.

The Contractor shall provide to the Employer’s representatives, free of cost, all reasonable facilities, equipment, and documentation necessary to satisfy the representatives that the RTUs and electrical equipment are being fabricated in accordance with the Specifications. The inspection rights described above shall apply to the facilities of the Contractor or the Contractor's subcontractor where the RTUs and electrical equipment are being manufactured. The inspection rights shall not apply to the facilities of subcontractors supplying unit components to the RTU manufacturer. Such items will be inspected and tested by the Employer's representatives at the main manufacturing site.

Inspections by the Employer’s representatives will include visual examination of the physical appearance of the RTU hardware and associated equipment along with all cable dressings, and labeling details. Contractor documentation will also be examined to verify that it adequately identifies and describes all RTU hardware, firmware, devices, and spare parts. The Employer shall have access to inspect the Contractor's and manufacturer's quality assurance standards, procedures, and records that are applicable to this RTU Construction. Inspection shall not relieve the Contractor of the responsibility for furnishing material and equipment conforming to the requirements of the Technical Specifications, nor shall such inspection invalidate any claim that the Employer may make because of defective or unsatisfactory RTU hardware or firmware, electrical equipment or design.

4.2 Training

The Contractor shall undertake to train free of cost, engineering personnel selected and sent by BESCOM, at employer site.

The period and the nature of training for the individual personnel shall be agreed upon mutually between the Contractor and BESCOM. These Engineering personnel shall be given training on installation, operation, or testing to enable those personnel to become familiar with the RTU being furnished by the Contractor.

The training program shall teach Employer staff the skills needed for configuration, verification and maintenance of RTU. Software training shall equip Employer staff with the skills required for System maintenance and expansion and for the preparation and integration of new functions. Hardware training shall qualify Employer staff to perform routine preventive maintenance and perform diagnostic tests on RTU.

Course Name	Attendees per cycle	Location	No of cycle	Estimated Working Days
RTU configuration and maintenance	10	Employer Site	2	2

4.3 Test Procedures

All equipment shall be tested in accordance with the Contractor's standard procedures. The Contractor shall submit a detailed description of these test procedures. This shall be preceded by the submission of an RTU test plan.

The RTU test plan shall be submitted for Employer’s approval prior to the start of factory tests. The corresponding test procedures shall be submitted for approval prior to the tests. The Employer will only approve test procedures if they are inclusive, thoroughly testing each section of the equipment. The Contractor shall use ANSI MC8.1, "Recommended Practice, Hardware Testing of Digital Process Computers," as a guide in preparing the RTU test procedures. The test procedures shall include the following:

1) The test schedule including provision for eight hours of unstructured tests to be performed by the Employer
2) The purpose of each test
3) The function to be tested
4) The plans/procedures to be followed
5) Specific references to project documentation for correlation with the procedures and for verification of the documentation
6) The test setup, equipment, and conditions for each part of the test
7) All test inputs and outputs
8) Test firmware descriptions and listings
9) A copy of any certified test data to be used in lieu of testing
10) Expected results
11) The acceptance criteria
12) A procedure for handling the variances that are identified during testing.

All RTU factory and field performance testing shall include use of the Data Acquisition and Control. Integration of the RTU with the DAS via the Employer's communications system.

4.4 Test Records

The Contractor shall maintain a complete record of the results of all tests. This record shall be keyed to the steps enumerated in the previously approved test plan. The record shall include the following items:

1) Reference to the appropriate section of the test plan
2) Description of any special test conditions or special action taken
3) Test results, passed/failed.

A copy of the test records shall be delivered to the Employer at the conclusion of the tests.

4.5 Type Tests

The RTUs offered in the tender should have been successfully type tested at National/international laboratories like CPRI, KEMA, ERDA in line with the relevant IEC standard and technical specification and all the type test report shall not be older than 10 (Ten) years. The bidder shall be required to submit complete set of the type test reports along with the offer. The list of type tests shall be as per the relevant IEC 60255-3, IEC 60255-5, IEC 60255-6, IEC 61000-4-2, and IEC 61000-4-3 to demonstrate that the RTUs comply with these standards. As a minimum, the following type tests shall be included:

1) Dielectric tests
2) Impulse voltage withstand tests
3) High frequency disturbance tests
4) Thermal requirement tests
5) Mechanical requirement tests
6) Limiting dynamic value tests
7) Contact performance tests
8) Electromagnetic radiation susceptibility tests
9) Electrostatic discharge susceptibility tests

4.6 Factory Tests

All RTUs shall successfully pass a set of routine tests before being accepted for delivery. These tests shall be performed by the Contractor and, at the option of the Employer, in the presence of two Employer's representatives. The routine tests shall be based on an approved subset of the test procedures. Expenses incurred for this testing will be borne by contractor. At least 10% of RTUs from each batch shall be subject to the complete set of approved test procedures. This complete testing shall be witnessed by the Employer's representatives and shall include, but not be limited to, all of the following functional and performance tests:

1. Inventory check and inspection for general appearance, cabling, drawing conformance, and labeling

2. Checks of proper functioning of all hardware and firmware by a thorough exercising of all RTU functions, both individually and collectively

3. Simulation of inputs, including noise and transient conditions, using convenient test panels which allow each input to be varied over its entire range via individual setters

4. Checks of power supply voltage margins, ripple levels, and short-circuit protection

5. Test of all digital input pointsTest of all control outputs

6. Test of power failure and recovery

7. Tests of communications and down-line loading of configuration changes

8. Test of equipment spares through substitution

9. Checks to verify the accuracy of hardware and firmware documentation

10. Demonstration of techniques and methods for modifying the database, including point additions and deletions

11. Tests conducted to verify the test set capabilities and operations. All on-line, offline, and remote diagnostic features and equipment shall be tested

12. Test under full-power and simulated operation for a minimum of 48 hours. Twelve hours of this test shall be at the specified high temperature limit. The RTU shall demonstrate continuous operation without any failures. This operation shall include periodic scanning of all points and demonstration that all RTU functions operate properly.

4.7 Continuing Support services

Subsequent to final acceptance, the contractor shall provide continuing technical support for the RTUs for a minimum ten-year period. This requires that both consultation with knowledgeable contractor technical personnel and support by

trained field service personnel be readily available to assist Employer personnel in correcting difficult RTU malfunction.

5. RTU Documentation

This Clause describes the requirements for design approval and documentation for the RTUs.

5.1 Documentation and Design Approval Process

To ensure that the RTUs and the electrical equipment and design to be supplied conform to the specific provisions and general intent of these Technical Specifications, the Contractor shall submit hardware, firmware, equipment and design documentation produced specifically for this project to the Employer for approval. The Employer will document their approval or submit comments to the Contractor within 10 working days after receipt of the documents. The Contractor shall not proceed with implementation of any hardware or firmware, equipment or design which has not been approved until documentation submitted for it is corrected or the Employer grants written permission for the Contractor to proceed. Corrected documents must be resubmitted by the Contractor to the Employer for approval as soon as possible. The Employer will review the resubmitted documents and record their approval or submit additional comments to the Contractor within 10 working days after receipt of the corrected document. No schedule relief is to be implied for documents requiring correction and resubmission to the Employer.

Documentation for the Contractor's standard hardware and standard firmware shall be furnished to the Employer for review, but approval will not be required. The Employer, however, reserves the right to determine that this standard hardware and standard firmware is in full conformance with the Specification, that it is consistent with other hardware and firmware in the RTU, and that the documentation is complete and correct in all respects.

In cases where the Contractor's standard hardware or standard firmware does not conform to the requirements of this Specification and modifications are required, the standard documentation along with documentation of the modification shall be submitted for the Employer’s approval.

Any purchasing, manufacturing, or programming implementation initiated prior to the Employer's approval of the relevant documents or drawings shall be performed at the Contractor's risk. The Employer shall have the right to request additional support documents, and require the Contractor to make any necessary changes to construct the RTUs in conformance with the provisions and intent of the Specifications without additional cost to the Employer. Documentation review and approval by the Employer does not relieve the Contractor of the overall responsibilities to satisfy the specified requirements.

5.2 Hardware Documentation

The Contractor shall provide documentation for all hardware supplied to the Employer. Documentation describing the circuitry, operation of the circuitry, and troubleshooting and maintenance procedures shall indicate the revision level of the hardware to which the documentation applies. Generic manuals are not acceptable unless they clearly show what is supplied with the system. This documentation shall satisfy the following requirements:

1. An inventory of the hardware to be supplied, including the manufacturer's name, model number, serial number, and other pertinent data

2. The physical planning/site preparation documents, containing detailed mechanical drawings of all cabinets and related hardware and indicating mounting details, clearance requirements, and environmental restrictions, as well as the electrical requirements of the hardware

3. The installation, wiring, and cabling diagrams. Terminations for connections shall be clearly identified with adequate space for cable and wire identifiers. Any special precautions associated with cabling shall be identified on this drawing.

4. The internal wiring diagrams, oriented toward the input and output field wiring terminal blocks. The wiring diagrams shall include:

    a) The identification of the terminal block and pin numbers

    b) Space to add the point name of at least 20 characters for each input and output point

c) Point type

d) The point's I/O card location

e) The point's address within the protocol

f) The point's signal conditioning (filtering, scaling, isolation, etc.) and the location of the conditioning (if not on the point's I/O card)

g) All jumper/strap positions.

5. The enclosure assembly drawings showing the location of the components, such as power supplies and printed circuit card chassis, and the subassemblies comprising the components to the level of printed circuit cards. The drawings shall identify each component and subassembly by part number and revision level.

6. All maintenance documentation, including manuals and other descriptive material, which will enable the Employer's personnel to maintain all Contractor-supplied equipment.

   The maintenance documentation shall include descriptions, specifications, theory of operation (including firmware listings where applicable), printed circuit module schematics and layout drawings showing components and position, mother-board schematics showing inter-module connections, back-panel and assembly wiring diagrams, pin lists, and other data on the electrical, electronic, and mechanical hardware.

   Instructions shall be included for preventive maintenance procedures consisting of examinations, tests, adjustments, and cleaning that should be performed periodically under normal operating conditions for the purpose of preventing failure or impairment of the equipment.

   The manuals shall include guidelines for isolating the cause of a hardware malfunction. The discussions shall contain concise information on how the hardware operates, troubleshooting guides for localizing faults, listings of possible sources of trouble, symptoms, probable causes, use of test equipment, use and interpretation of built-in RTU test functions, and instructions for remedying faults.

Complete parts lists and breakdowns, and descriptions sufficient to identify each component and ordering information for these parts shall be included in conjunction with maintenance manuals. Every component subassembly and assembly shall have a unique part number assigned to it. This part number shall coincide with the markings on the hardware itself and shall be used in the documentation whenever the hardware element is referenced.

7. A thorough description of the RTUs communications protocol implementations. The data formats used and the relationship of I/O card locations/addresses to message fields must be clearly presented.

8. Operation and maintenance documentation for the test set, similar in content and detail to the RTU documentation.

The Contractor shall describe, by title and by content outline, the specific documents that be provided to the Employer. The documentation described by items (1) through (8) above, and required for RTU installation, shall be provided within two (2) months after contract award.

5.3 Firmware Documentation

The Contractor shall supply documentation for all firmware provided with the RTUs. This documentation shall include the following information as a minimum:

1. An inventory of all programs and modules to be provided and a cross referenced index to the firmware documentation

2. A functional overview document, which describes the firmware on a subsystem basis and includes a brief description of the hardware interfaces. This document shall functionally describe all firmware to be provided with simplified block/flow diagrams. This document shall be provided within two (2) months after contract award and prior to the issuance of any individual firmware documents.

3. A firmware documentation standards manual shall be provided within two (2) months after contract award for the Employer's review, which defines in detail the documentation format for items (4) and (5) below.

4. Existing design documentation and user's manuals for the Contractor's standard firmware that satisfies the requirements of the Specifications submitted to the Employer in their existing form.

5. Standard firmware that requires modification to fulfill the Employer's requirements shall be subject to review and approval. The standard documentation and the change documents shall be submitted prior to the implementation of the changes by the Contractor. All changes to the Contractor's standard firmware shall be identified.

5.4 Test Documentation

The Contractor shall provide documentation for all factory and field tests as per Clause 4, RTU Inspection and Test.

5.5 Final Documentation

Final documentation shall consist of the documents necessary to satisfy the requirements in Clause 5.2, Hardware Documentation, Clause 5.3, Firmware Documentation, and Clause 5.4, Test Documentation. The documentation will be used by the Employer personnel for RTU operation and maintenance after RTU acceptance. Final documentation shall be delivered within three (3) weeks after the RTUs/SPBs are shipped.

Each document shall be identified by a Contractor document number. Where a document is revised due to a change in design (or for any other reason), each revision shall be indicated by a number, date, and subject in a revision block and shall include an indication that the document has been approved by the Contractor's project manager.

All drawings prepared specifically for the Employer shall be provided on Hard Disk in a format acceptable to the Employer. Drawings and documents shall be provided in native format such as AutoCAD and MS Word with PDF copies to confirm as delivered. All RTUs shall be delivered with a set of full size wiring and cabinet layout drawings

The Contractor shall be responsible for supplying documentation revisions or changes due to inaccuracies, installation requirements, omissions determined by usage, and design or production alterations to the RTUs. Changes shall be issued in

the form of replacements for the affected drawings, diagrams, charts, graphs, tables, lists, and pages in the various manuals prior to the start of the field performance test.

5.6 Document Quantities

The quantity to be supplied for each document is shown in Table 5-1, RTU Document Quantities. Copies of documentation provided at training courses are to be supplied in addition to these quantities. The Contractor shall identify any specific differences where the Contractor's documentation set differs from the named items in this list.

Table 5.1: RTU Document Quantities

DOCUMENTS	REVIEW OR APPROVAL QUANTITIES*	FINAL QUANTITIES
HARDWARE DOCUMENTATION		
1. Inventory of Hardware	1	3
2. Site Preparation Manual	1	3
3. Installation, Wiring & Cabling Diagram	1	3 + 1 per RTU
4. Assembly Drawings	1	3 + 1 per RTU
5. Maintenance Manuals for RTUs	1	3 + 1 per RTU
6. Test Set Documentation	1	3
FIRMWARE DOCUMENTATION		
1. Inventory of Firmware	1	3
2. RTU Functional Overview	1	3
3. Firmware Documentation Standard	1	3
4. Standard Software Manuals	1	3
5. Modified Standard Software Manuals	1	3
TEST DOCUMENTATION		
1. Test Plan	3	3
2. Test Records	-	3 + 1 per RTU

5.7 Test Documentation

The Contractor shall provide documentation for all factory and integration tests as per Clause 4, RTU Inspection and Test.

OUTSTATION DEVICE PROFILE REMCOMMEDATATION

Functionality	DNP Objects to be supported (All its variations are to be supported)
Time Synch	50
Status Values	2
Analog Values	30
Analog Deadbands	34
Analog Outputs	41
Counters	21
Control	12
Default Poll (Status): Digital Inputs Binary Outputs Binary Counters Frozen Binary Counters Analog Inputs Analog Outputs	 1 10 20 21 30 40
Double bit Binary Input	3
File	70
Authentication	120
Security Statistics	121
Online/Offline Processing at the RTU	
CROBs (Control Relay Output Blocks)	

Function Code	Function
0	Confirm
1	Read
2	Write
3 and 4	CROBs (Select and Operate)
13 and 14	Cold and Warm Restart
19	Save Configuration
20	Enable Unsolicited Responses
21	Disable Unsolicited Responses
23	Delay Measurement
24	Record Current Time
25	Open File
26	Close File
27	Delete File
30	Abort File
28	Get File Information
29	Authenticate File
31	Activate Configuration
32	Authentication Request
33	Authentication Requeste No Acknowledgement
129	Response
130	Unsolicited Response
131	Authentication Response

Static Data and Event Data	Group 60
Binary Inputs	Group 1
Double-bit Binary Inputs	Group 3
Binary Output Status	Group 10
Counters and Frozen Counters	Group 20 and 21

Analog Inputs and Frozen Analog Inputs	Group 30 and 31
Analog Output Status	Group 40
File Transfer Objects	Group 70
Authentication	Group 120
Security Statistics	Group 121
Analog Input Reporting Deadbands	Group 34
Internal Indications	Group 80

The Contractor shall comply any new requirement which may arise during project implementation phase in addition to the functionalities specified in the Outstation Device Profile Recommendation above.